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Performance Analysis of Double Layer Waveguides for Optical Interconnection System

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Abstract: This study compares the simulation results of transmission performances between polymeric waveguide system and silica fiber waveguide system. These two waveguides were designed to have double layer transmission system. Polymeric waveguide showed-0.132dB loss, but silica fiber waveguide showed-3.0dB. Eye diagrams, crosstalks and BER of two systems are compared by Matlab code and polymeric waveguide system showed better signal shape and crosstalk than silica waveguide system.

Key words: Optical interconnection, polymeric waveguide, silica fiber waveguide, alignment

INTRODUCTION

Recent Microprocessor Units (MPUs) have been developed with a clock speed of several GHz. The data processing speed in networks systems and server computers is still limited (Forbes *et al*., 2001) below several hundred Mbps due to the low data transmission rate through electrical interconnection lines between boards and between MPU/memory chips in the system. The optical interconnection can give a lot of advantages over electrical interconnections. At present, the optical interconnection can be a unique solution to solve many problems of the electrical lines in operating speed, dense packaging and power dissipation etc (Leui, 2000; Lytel *et al*., 2000; Swage, 2002).

Many types of transmission mediums for optical interconnections (Levi, 2000; Lytel *et al*., 2000; Swage, 2002; Kirk *et al*., 2003; Whiteman and Johnk, 1999; Ishi and Koike, 2003; Mederee and Jagar, 2001; Meis, 2003; Cho and Chu, 2004; Chu *et al*., 2005) have been developed, such as free space optics; fiber ribbons and planar waveguides. However, they require bulky connectors to interconnect fibers and as much they are not easily applied in chip-to-chip optical interconnections. In this study we have designed an optical interconnection system over double layers polymeric waveguide as well as silica fiber on optical printed circuit board where Vertical Cavity Surface Emitting Laser (VCSEL) and Photodiode (PD) arrays, driver and receiver ICs and silica fibers/ polymeric waveguides are hybrid-integrated on the same board. This approach is developed in an effort to realize a compact, less loss, less cross talk and cost effective process without bulky optics, fiber ribbons, or connectors. In this study we investigated that interconnection system over 2 layer polymeric waveguide is more reliable than silica fiber based interconnects as compared their performances.

Performance analysis: In this research we have considered two systems: Double layers polymeric waveguide interconnection system and silica fiber interconnection system. We have used optical transmission system design tool " Light Tool, Version. 5.0 and also Matlab coding for analyzing the systems.

Polymeric waveguide interconnects: We have considered a polymeric material of cubic cross section of length, L = 50 mm, width = 125 um and thickness = 125 um with 45° ended mirror planes both the Tx and Rx sides. Core refractive index is 1.45 and cladding refractive index is 1.47. The polymeric waveguide configurations are shown in Fig. 1 (a) and (b).

At the both two end points of each waveguide, 100 um above from the each waveguide upper surface, VCSELs and receivers are mounted. The VCSEL ray number is 1000, in the receiver total received number of rays were counted.

In polymeric waveguide case, the average received number of rays were 970, therefore, the loss of transmission is 10log (970/1000)= -0.132dB, it is negligibly small loss. As the Simulation result in Fig. 2 (a) shows, there is little leakage of light beam through transmission.

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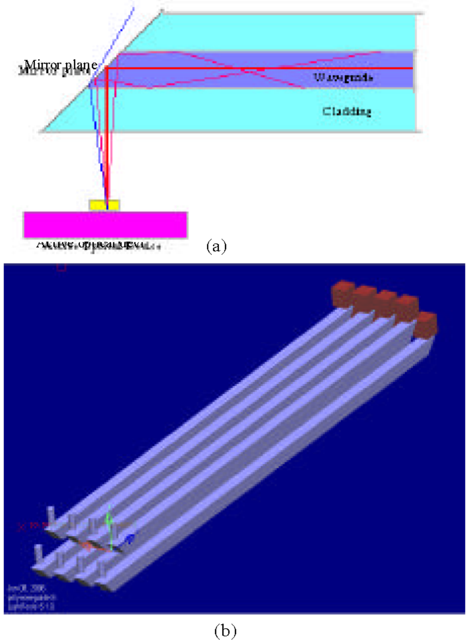

Fig. 1: Polymeric waveguide configuration. (a) 45° ended mirror plane. (b) Double layer polymeric waveguide

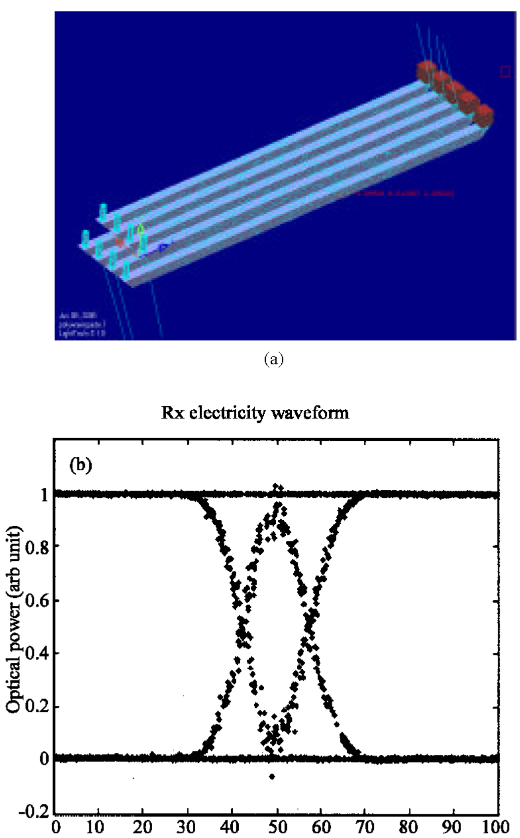

Fig. 2. Test result-polymeric waveguides. (a) Light Tool simulation result (b) Matlab codding eye-diagram

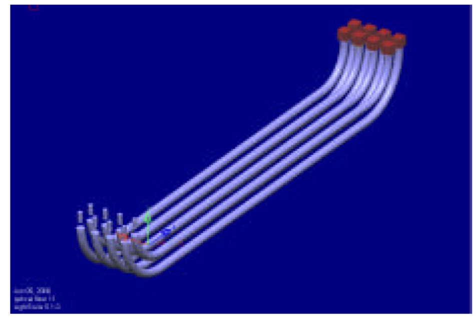

Fig. 3: Double layer optical fiber configuration

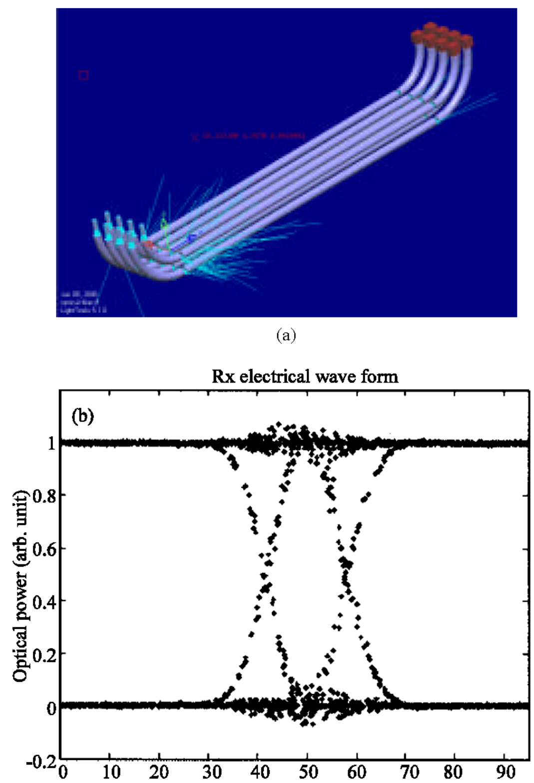

Fig. 4: Test result-silica fiber. (a) Light Tool simulation result (b) Matlab codding eye-diagram

Even some losses in receiver can be controlled by adjusting the location of receiver. The reason of this good transmission result might be come from the fact that there are only 2 alignment points in polymeric waveguide system which are VCSEL to waveguide and waveguide to receiver, this can accomplish good performance compared with the 4 alignment points in silica fiber transmission system in Fig. 2 (a) which are included more 2 alignments points of fiber to fiber. In Fig. 2 (b), Matlab code eye diagram result also shows good shape with low loss transmission.

Silica fiber interconnects: For this system, we used silica material glass fiber having 100 um core diameter, 125 um cladding diameter, 50mm length, core refractive index 1.45 and cladding refractive index 1.47. The silica fiber waveguide configurations are given in Fig. 3. In this study, same component parameter values were used.

In Fig. 4 (a), transmission simulation result is described. It is clearly recognized that there is much loss caused by the leakages at 4 alignments points.

The average number of received rays through the transmission is 500, therefore, the loss is 10log (500/1000)= -3.0dB, much higher loss than that of polymeric waveguide transmission system. In Fig. 4 (b), the Matlab code simulation result also shows lossy and noisy signal shape.

RESULTS AND DISCISSION

The performance of optical transmission system of polymeric waveguide is much better than silica fiber waveguide transmission system. The loss of polymeric waveguide system is-0.132dB and the loss of silica fiber waveguide system is-3.0dB. The reason of this difference is can be considered two main aspects.

First, there is a difference in number of alignments points between silica fiber case and polymeric case. In polymeric waveguide system case, the system has only two alignments points at VCSEL to waveguide and waveguide to receiver, however silica fiber waveguide system has two more alignments points at 90° bent fiber to fiber and fiber to 90° bent fiber. Therefore, It is practically possible to happen the light leakage in silica waveguide system case.

Secondly, in silica waveguide system, since the 90° bent fibers exist, transmitted light may go out of the fiber. It can be recognized visually from the Light Tool simulation results in Fig. 2 (a) and Fig. 4 (a).

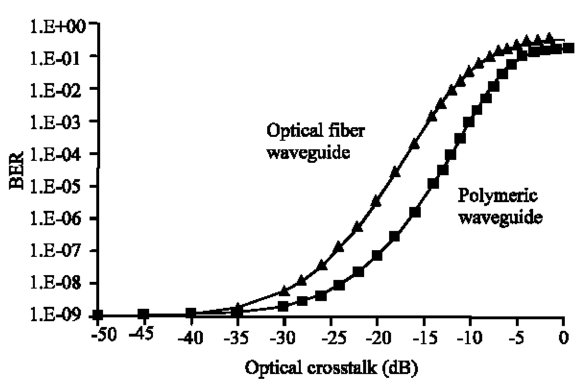

Fig. 5: Crosstalk comparison

From the Matlab code simulations of these two systems, polymeric waveguide system has much better shape than silica waveguide system. Figure 5 Shows the Matlab BER coding results by which it is clear that polymeric waveguide has lower crosstalk and BER than silica fiber waveguide.

CONCLUSIONS

The transmission performance comparison between Polymeric waveguide system and silica fiber waveguide system was considered. These two waveguides were designed to have two layers transmission system. Through the simulation of Light Tool software, polymeric waveguide showed better transmission performance over silica fiber waveguide. By using Matlab code, eye diagrams of two systems are compared and polymeric waveguide system showed better signal shape and crosstalk than silica waveguide system. The main reasons of better performance of polymeric waveguide system is caused by the decreased number of alignment points and linear waveguide shape.

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